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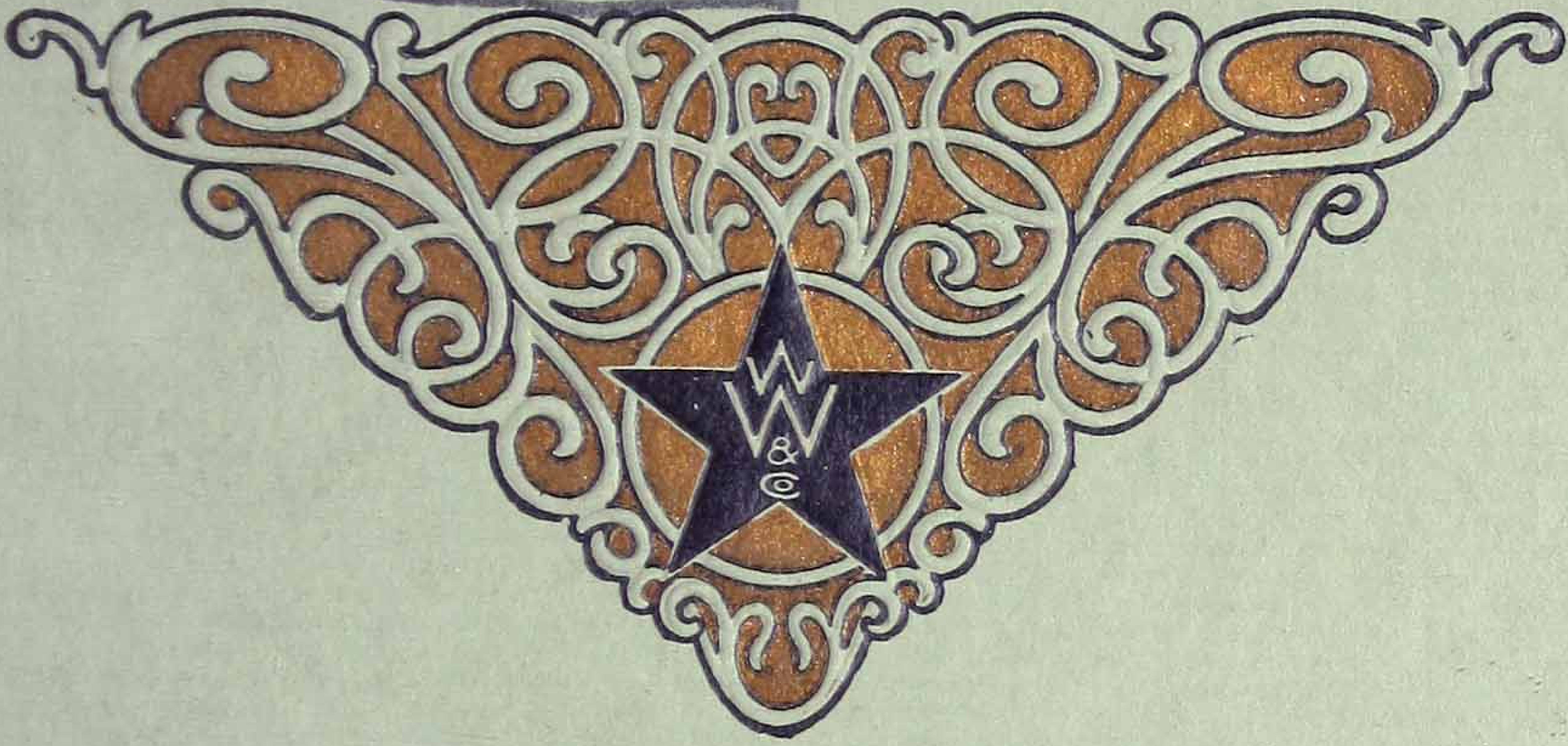
THE WEBSTER SYSTEM *of* STEAM CIRCULATION *for* HEATING PURPOSES



WARREN WEBSTER & CO.
CAMDEN, N.J.

ILLUSTRATING AND DESCRIBING

THE WEBSTER

SYSTEM OF STEAM CIRCULATION FOR HEATING PURPOSES

PART
FIVE

GENERAL
CATALOGUE

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CAMDEN, N. J.

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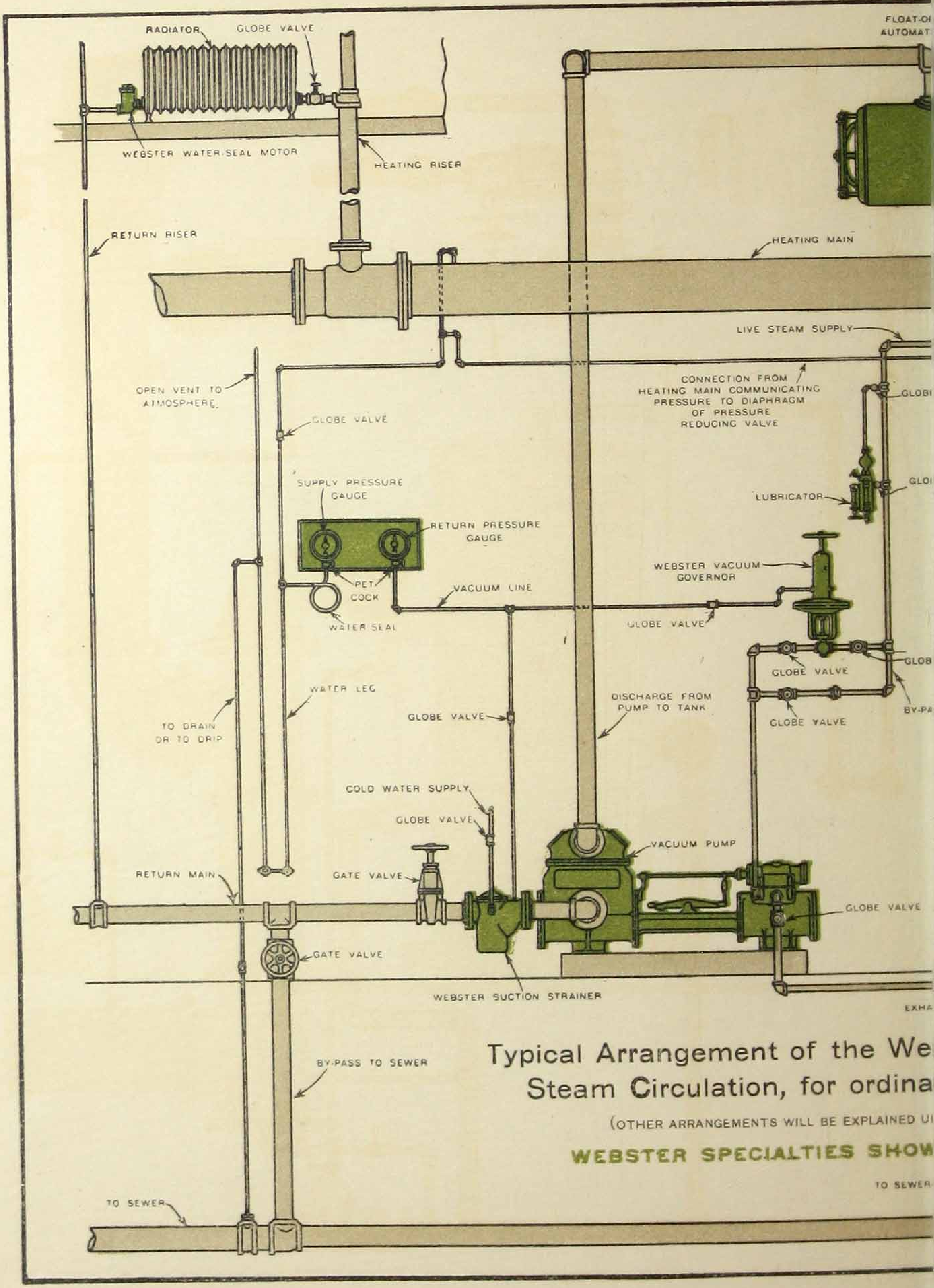

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WEBSTER SPECIALTIES SHOW

CIRCULATION FOR HEATING PURPOSES

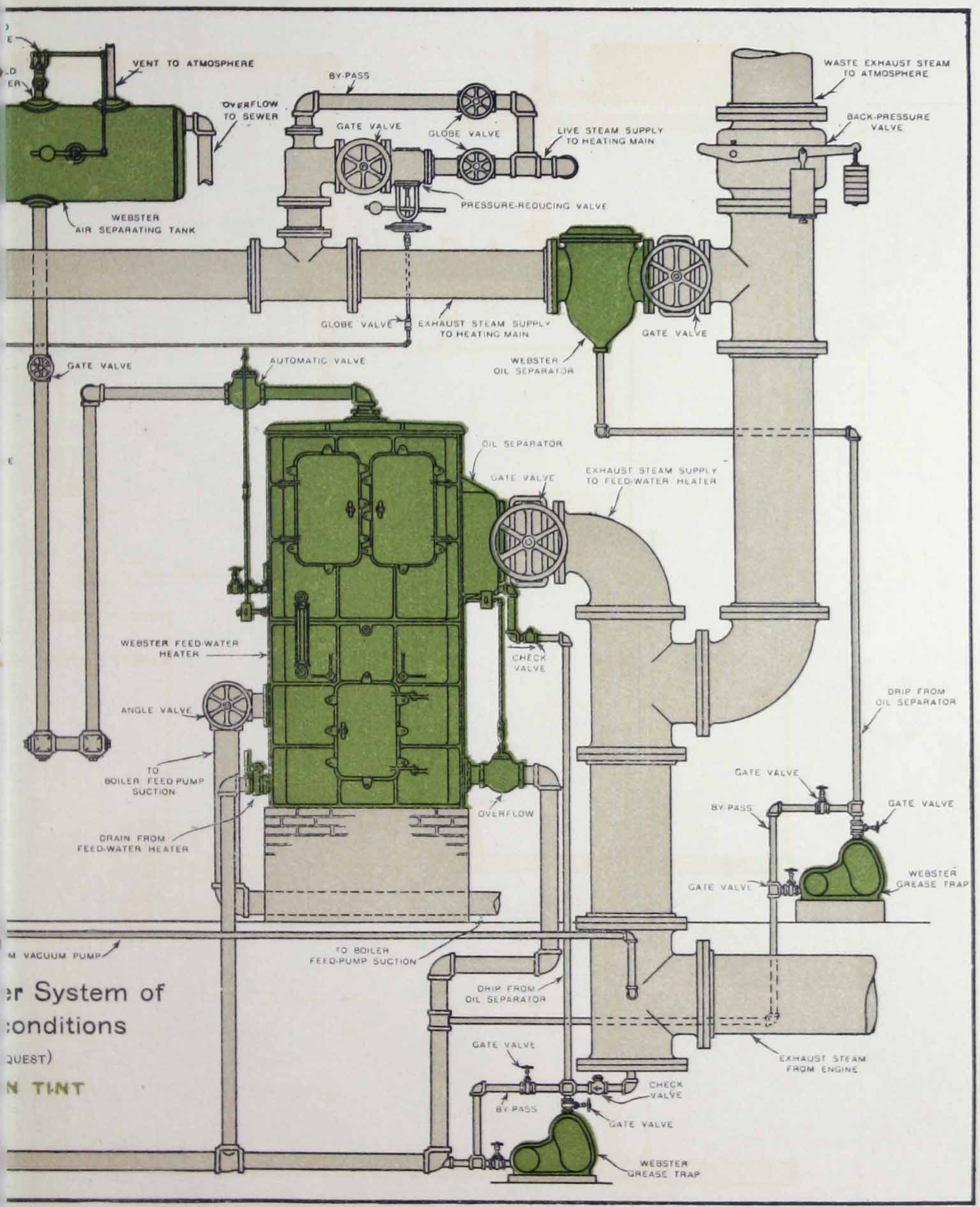

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TABLE OF CONTENTS

PAGE
Announcement, 4
About Ourselves, 5
Our Organization, 5
Steam Heating in General, 6
Difficulties Encountered, 7
The Heating Medium, 7
Requirements for an Effective Steam Heating System, 9
The Webster System, 10
Discharge of Water and Air from Radiators and Mains, 12
Back-Pressure and Its Effects, 13
Minimum Back-Pressure, 16
Equable Steam Distribution, 17
Removal of Condensation, 18
Lifting the Condensation, 18
Water-Hammer, 18
Air-Binding and the Removal of Air, 19
Modulation of Temperature, 21
Application to the Blower System, 22
Efficiency with Compound Engines, 22
Condensing Plants, 22
Changing Live to Exhaust Steam Heating Systems, 23
Live Steam Installations, 23
Pipe Sizes, etc. 24
Central Heating Plants, 25

CIRCULATION FOR HEATING PURPOSES

PAGE

OTHER APPLICATIONS, ... 26

ADVANTAGES, ... 26

EVIDENCE, ... 28

WEBSTER FEED-WATER HEATER AND PURIFIER, ... 30

- Water Supply, ... 30
- Steam Supply, ... 31
- Oil Separation, ... 32
- Heating Chamber, ... 32
- Filter, ... 32
- In General, ... 32

ILLUSTRATIONS

PAGE

SHOWING ARRANGEMENT OF THE WEBSTER SYSTEM OF STEAM CIRCULATION IN CONNECTION WITH A WEBSTER FEED-WATER HEATER, ... Fig. 1 Insert

WEBSTER STANDARD HORIZONTAL OIL SEPARATOR, Fig. 2 10

THE WEBSTER WATER-SEAL MOTOR, ... Fig. 3 11

WEBSTER SUCTION STRAINER AND CONDENSER HEAD, Fig. 4 10

WEBSTER FEED-WATER HEATER, ... Fig. 5 30

WEBSTER VACUUM GOVERNOR, ... Fig. 6 11

WEBSTER COMBINATION GAUGES, ... Fig. 7 12

WEBSTER FEED-WATER HEATER:

- Automatic Water Supply, ... Fig. 8 30
- Exhaust Steam Inlet, showing Separator Baffles, Fig. 9 31
- Heating Trays . . . . Fig. 10 31

TABLE OF CONTENTS

	PAGE
Announcement,	4
About Ourselves,	5
Our Organization,	5
Steam Heating in General,	6
Difficulties Encountered,	7
The Heating Medium,	7
Requirements for an Effective Steam Heating System,	9
The Webster System,	10
Discharge of Water and Air from Radiators and Mains,	12
Back-Pressure and Its Effects,	13
Minimum Back-Pressure,	16
Equable Steam Distribution,	17
Removal of Condensation,	18
Lifting the Condensation,	18
Water-Hammer,	18
Air-Binding and the Removal of Air,	19
Modulation of Temperature,	21
Application to the Blower System,	22
Efficiency with Compound Engines,	22
Condensing Plants,	22
Changing Live to Exhaust Steam Heating Systems,	23
Live Steam Installations,	23
Pipe Sizes, etc.	24
Central Heating Plants,	25

MANUFACTURERS OF
Webster "Star-Vacuum" Feed-Water Heaters and Purifiers
Webster Steam and Oil Separators
Webster Air Washers and Humidifiers
Webster Engineering Specialties for use with the
Webster System of Steam Circulation for Heating Purposes

We are pleased to send with this a copy of ou
describing the Webster System of Steam Circulation f
Purposes.

From it we trust you may be able to obtain a
standing of what this System will do, and how it doe

We have endeavored to present the subject in
manner to the architect, engineer or owner who desir
obtainable efficiency in steam heating, and need onl
to the 4000 installations already made, in every con
character of building, to assure you that the Webste
everything that we claim for it.

We invite correspondence relating to the Webs
Webster Feed-Water Heater, or the Webster Separators
Oil, and will gladly furnish the special information
understand their application to any particular plant

We thank all who have contributed to our succ
past twenty years, and assure you that we shall ende
the same high standard in manufacture and organizati
made the Webster System and Specialties so widely and

With best wishes for the coming year, we are,

Yours very t

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ANNOUNCEMENT

WE have pleasure in presenting the Fifth Edition of Part V of our general catalogue, descriptive of the Webster System of Steam Circulation for heating purposes.

In this edition it is our object to show, a little more fully than heretofore, the great possibilities of a system of steam circulation without pressure, and we hope that it will at once prove interesting and assist in maintaining confidence in our ability to fulfill our promises and claims.

Over one thousand new installations of the Webster System have been made in the three years prior to the publication of this edition of our catalogue, and these have not been confined to any particular section of the country, but are well distributed throughout the different states.

The diversified character of the buildings represented in the list given in this pamphlet indicates the wide range of adaptability of the Webster System and the great variety of heating problems with which we come in contact.

We wish to assure those interested in the heating of buildings that we shall continue to concentrate our energies upon the perfection of the various details connected with the economic utilization of exhaust steam, the circulation of live steam at low pressure and the constant improvement of the mechanical and engineering details involved in the Webster System and our other Specialties. We intend to leave nothing undone in the future to perpetuate our success in this department of engineering.

October, 1907. WARREN WEBSTER & CO.

CIRCULATION FOR HEATING PURPOSES

ABOUT OURSELVES

CONFIDENCE, it is said, is a "plant of slow growth." Reputation is not built upon a single success. For nearly twenty years this company has been engaged in the economic utilization of exhaust steam for warming buildings and for heating feed-water for steam boilers.

The Webster System and Specialties are all covered by letters patent of the United States and foreign countries. At present we have over eighty patents and fifty applications for patents in the United States alone, and are constantly securing others as new improvements are developed, for it has been and is our policy to develop our devices and their application to the highest point of efficiency.

Our Organization

We regularly employ a corps of expert engineers who have made a special study of the various and often intricate problems bearing upon the utilization of exhaust steam for heating and manufacturing, and, as a result of their labors and experience, marked progress has been made in improved methods for its application and use.

These special engineering facilities enable us to determine the best methods for any general or special installation, and in this connection we desire to state that no general rules of procedure can be adhered to, owing to the widely varying conditions.

We are prepared to make critical and exhaustive examinations of power and heating plants to determine the measure of economy attainable by the use of the Webster appliances, and based upon the intimate knowledge of existing conditions thereby gained, we are prepared to submit detailed proposals (backed by guarantee), for the attainment of such results as our experience shows to be practicable in any case under consideration.

To the preparation of such proposals we bring a vast amount of experience obtained along these special lines of engineering practice, which has enabled us to render valuable aid to our clients all over this continent.

THE WEBSTER SYSTEM OF STEAM

We cordially invite correspondence from any one interested in cutting down the cost of heating or the amount of fuel used; such inquiries will promptly command our best attention.

To consulting engineers we will gladly furnish information and details suitable for plans and specifications, either for the entire Webster System installation in new buildings, or for changes in existing heating plants that may be necessary to apply this system.

We cordially invite correspondence or consultation with our nearest office from any one desiring special information in relation to our Specialties, which, in addition to the Webster System described in this catalogue, include the Webster Feed-water Heaters and Purifiers, Webster Feed-water Heaters and Chemical Purifiers, and Webster Separators for Steam and Oil. The particular and peculiar advantages of each are fully described in separate sections of our general catalogue, which we will be pleased to mail upon inquiry.

STEAM HEATING IN GENERAL

IN the simplest heating plants steam is taken directly from the boilers, the pressure throughout the system being practically the same, the condensation returning by gravity.

Care must be taken in arranging the piping to avoid the backing up of condensation and water-hammer.

In buildings of any size steam at considerably higher pressure than that needed for heating is generally required for operating engines or pumps, for steam cooking or for other service, which has led to the adoption of the reduced-pressure heating system, in which the steam pressure is reduced from that in the boilers to that desired in the heating system, by causing it to pass through a pressure-reducing valve.

In these systems the water of condensation from the radiators is not always returned to the boilers, and even today in many live steam plants the condensation is trapped to the sewer.

Until comparatively recent years little attention has been given to the utilization of exhaust steam for heating.

CIRCULATION FOR HEATING PURPOSES

Difficulties Encountered

In the early days when exhaust steam was first used, no attempt was made to save the condensation, as any effort in this direction, or, in fact, any attempt to secure circulation, often involved such excessive back-pressure upon the engines that, under some conditions, it proved more economical to use steam directly from the boilers, and to waste the exhaust to the atmosphere. When the condensation is returned by gravity, this method of heating is known as the back-pressure gravity system, which consists of a system of supply mains of very large area in proportion to the radiating surface supplied, and a system of returns discharging through traps or water-seals to a tank from which the condensation is pumped back into the boilers. Vents are provided for the removal of air from the coils.

Experience proves that this system is only partially successful. Even in plants of this description involving the best practice the following difficulties are likely to be encountered: excessive back-pressure, air-binding, water-hammer, absence of control, and difficulty in freeing the system of condensation.

Of recent years the enormous increase in the number of combination heating and power plants and the greatly stimulated interest in economic developments of every description, have called a halt upon the wasteful methods of the past, and a widespread and imperative demand has sprung up for the utilization of the vast amount of heat previously dissipated with the escaping exhaust steam.

The advantages offered by the use of this medium for heating purposes is evident, but its successful utilization is beset with numerous physical difficulties, all of which must be overcome before real efficiency and economy are secured.

The Heating Medium

While the erroneous notion prevailed in the past that live steam is better adapted to heating service than is exhaust, it has been demonstrated that exhaust steam, when rid of its entrained oil and water by passing it through an efficient separator, is in every way suited to the requirements of a steam heating system.

While the heat given off per square foot of direct radiation is greater with high-pressure steam than with low, owing to the greater difference in temperature between the steam inside the radiator and the air outside, an inspection of a table showing the properties of saturated steam shows that pound for pound exhaust steam has a greater heating power when condensed to water at the steam temperature than has live steam at much higher pressures.

A point that has only recently been brought out is of interest in this connection, viz., that low-pressure heating appears to be considerably more efficient than high.

In a paper presented by Mr. H. O. Lacount at the May, 1907, Meeting of the American Society of Mechanical Engineers, results of tests were given which show that the fuel cost for heating a given space by low-pressure steam was far less than that where steam at relatively high pressures was used.

The greater economy in heating secured by the use of low-pressure steam as the heating medium is no doubt in large measure due to the fact, as pointed out several years ago by Prof. J. H. Kinealy, that a radiator at high temperature keeps the air near the top of the room at a much higher temperature than when the radiator is filled with steam at a lower pressure and is not so hot. He says:

"The higher the temperature of the air at the ceiling of the room the greater will be the average temperature of the air in contact with the cooling windows and walls of the building, ... and hence the greater will be the amount of heat transmitted through the cooling walls and windows per hour. . . . . . That system of heating must undoubtedly be the best and the most economical which will maintain the desired temperature of the room nearly uniform from the floor to five feet above it, with a low temperature in the upper part of the room, and this is, I think, done by radiators supplied with steam at low temperatures."

Furthermore, since radiators and coils are commonly placed near the outside walls, it follows that the loss of heat by transmission through these walls must be greater with high-pressure steam than with low.

CIRCULATION FOR HEATING PURPOSES

Requirements for Effective Steam Heating System

Mr. R. P. Bolton, in a paper read before the American Society of Heating and Ventilating Engineers, mentions the following primary requirements for an effective exhaust steam heating system:

1. Absence of "back-pressure" on motive engines, so that they can be designed for highest economy, and work under designed conditions.
2. Effective drainage of condensation from the system of supply piping, prior to the entry of the steam to the radiating surface.
3. Effective drainage of condensation from the interior heating surfaces, as and when accumulated.
4. Continuous removal of air and its contained moisture from all confined spaces, without retarding the removal of moisture.
5. Removal of water and air from some distance below the lines of gravity drainage.

These should be accompanied by:

6. A variable capacity of removal adjustable to the extent of use of the heating surfaces, resulting in—
7. Regulation of temperature in separate radiating surfaces.

"It will readily be observed that the requirements above recited are not fulfilled by any system employing one pipe for a supply of steam and for the return of condensation, nor by any system which removes only the air-gases and does not deal with equal certainty with the water of condensation, nor by any arrangements establishing a partial suction in a coil or radiator in such a way as to act in opposition to the free drainage of the condensation, nor by any apparatus requiring more than one hand-valve for the regulation by unskilled persons of a coil or radiator, nor by any system incapable of lifting the condensation from a point somewhat lower than that of the outlet or of final disposition."

THE WEBSTER SYSTEM

THESE requirements are all met by the Webster System of Steam Circulation which we will now describe.

This system is commonly installed somewhat as indicated in figure 1, which illustrates the main features of this method of heating; the details varying of course, depending upon local conditions.

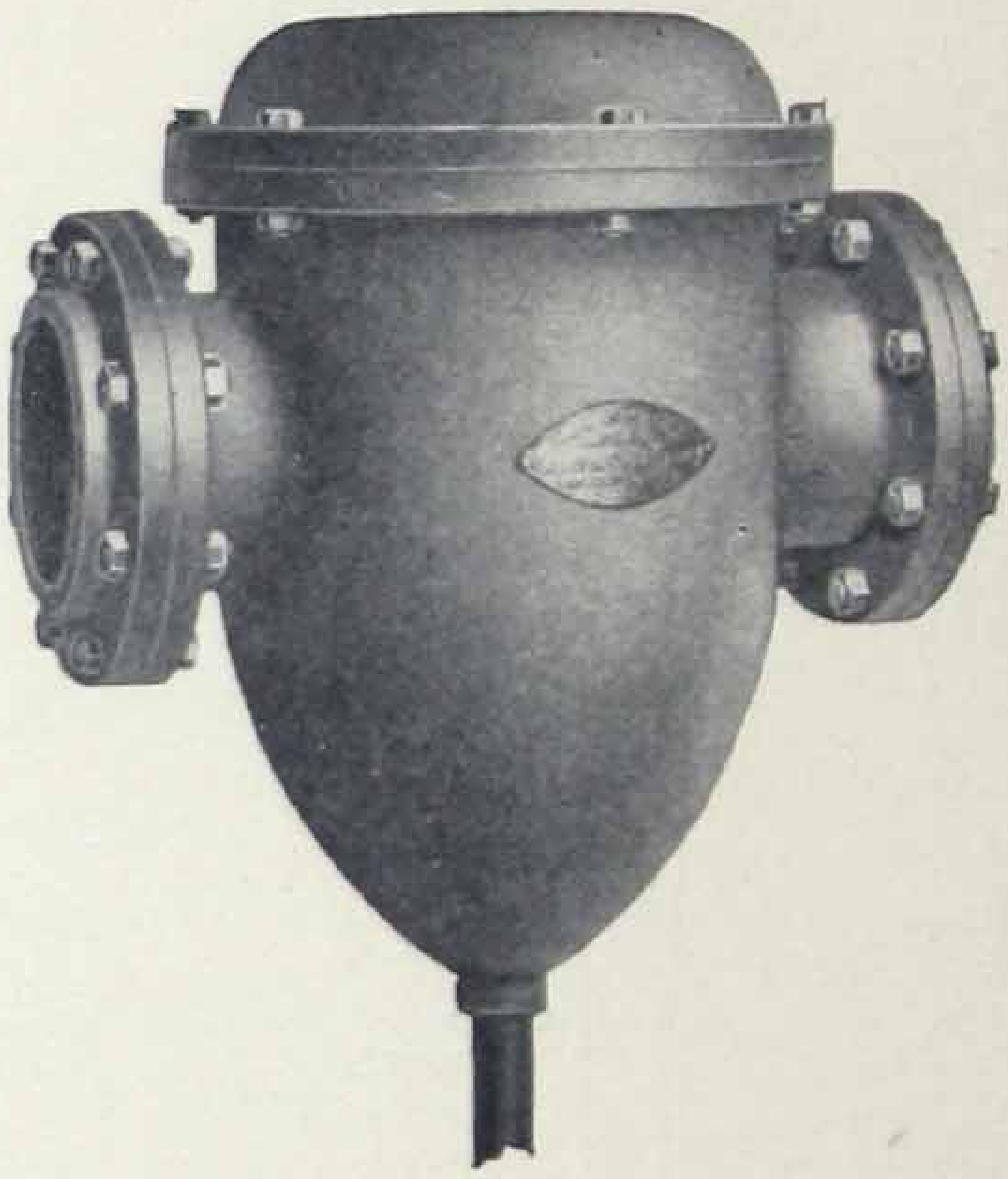

FIG. 2. WEBSTER OIL SEPARATOR.

The exhaust pipe from the engine and pumps branches to the feed-water heater and to the heating system, any surplus steam escaping to the exhaust-head on the roof, through the back-pressure valve.

The exhaust steam in its purified state having passed through the Webster Oil Separator (figure 2) is carried to the radiators or coils through a system of distributing mains and risers, either up-feed or down-feed, according to the character of the building in which the system is installed.

A pressure-reducing valve, shown in figure 1, is connected with the heating main leading to the distributing system. It is the function of this valve to make up any deficiency in the volume of exhaust steam supplied, and to provide for automatically admitting live steam at times when the engine is not running.

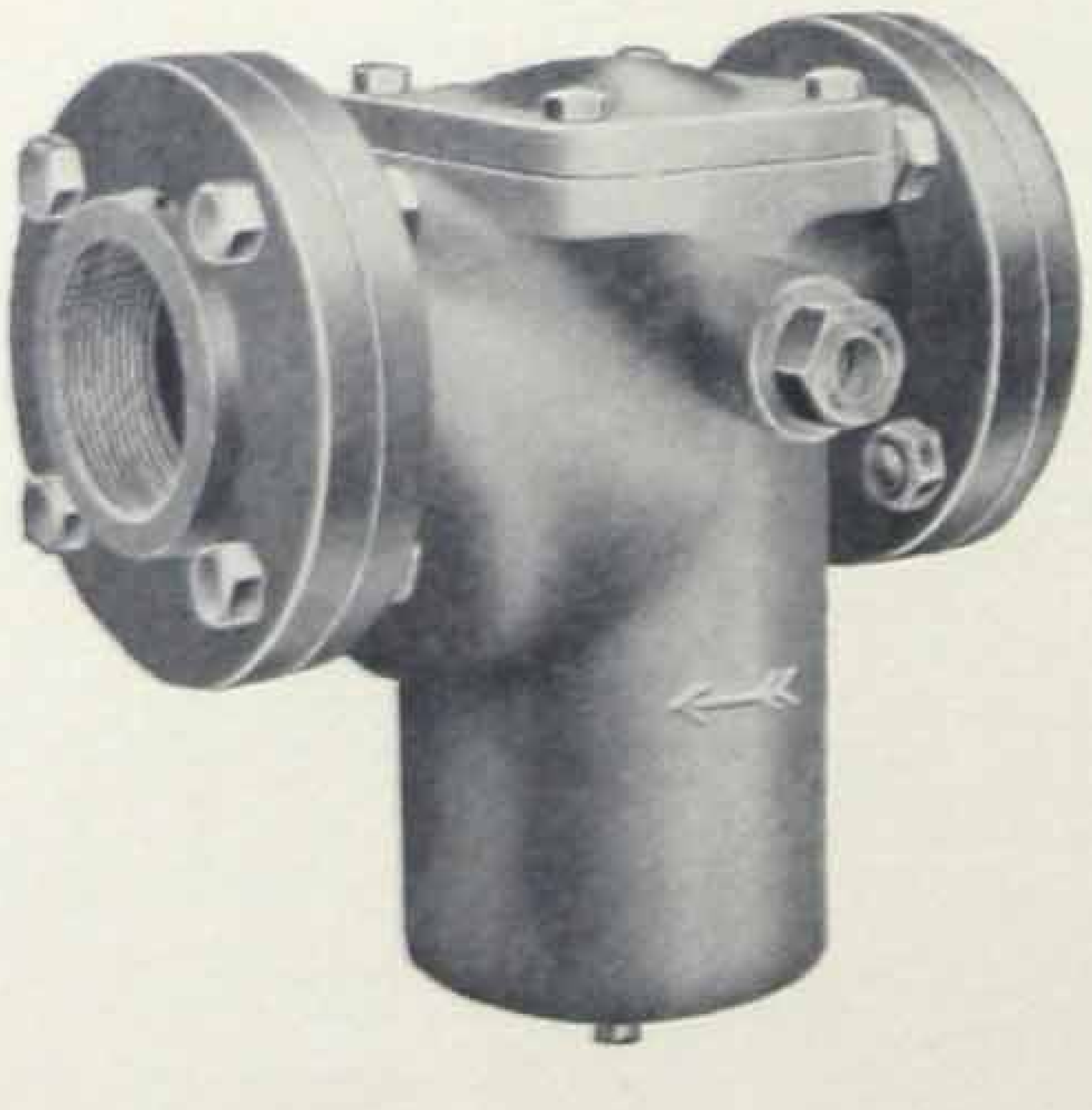

FIG. 4. WEBSTER SUCTION STRAINER.

Branches lead from the supply-mains or risers to the radiators, these branches being arranged so that any condensation will always drain toward the risers.

At the return end of each radiator or coil is placed a Webster

CIRCULATION FOR HEATING PURPOSES

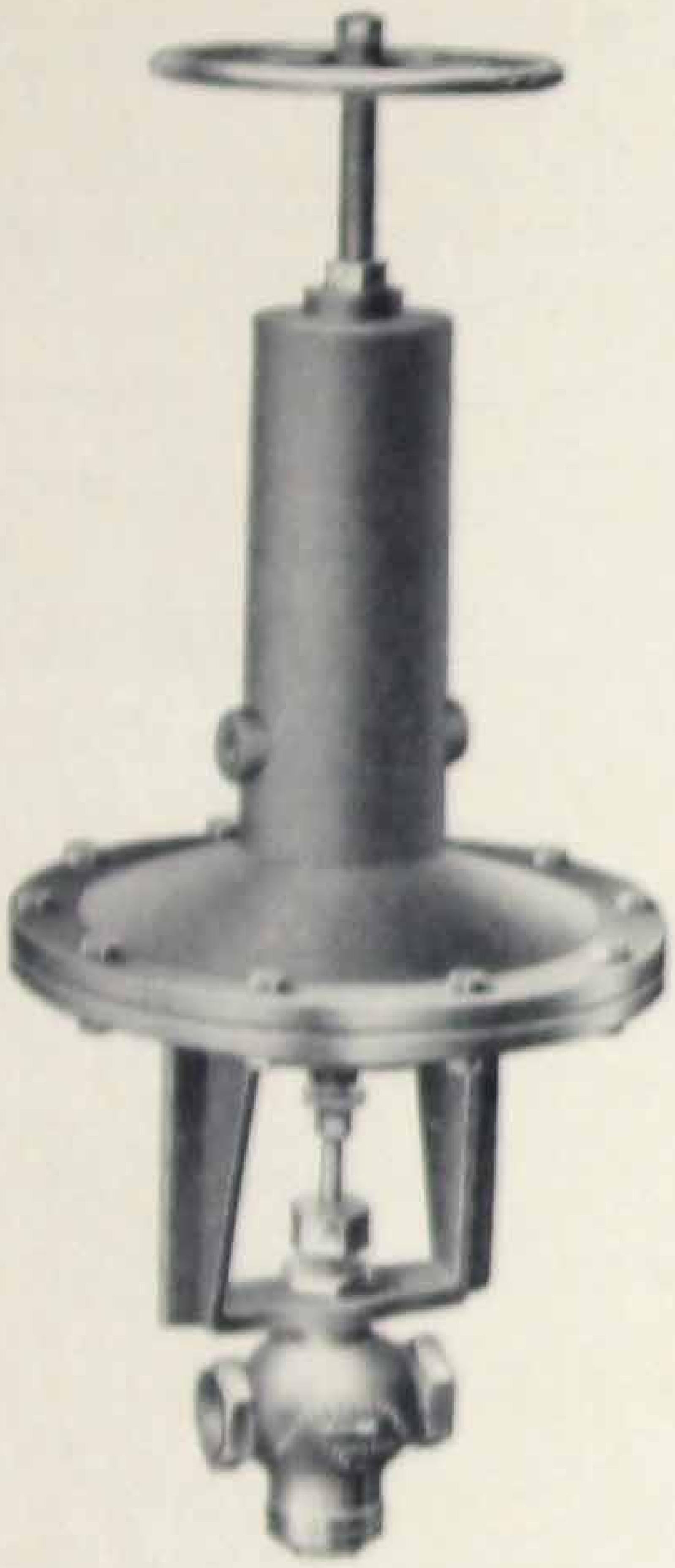

FIG. 6. WEBSTER VACUUM GOVERNOR.

Water-Seal Motor (figure 3) designed to prevent the escape of steam into the returns, while freely permitting the discharge of air and water thereto. Pipe connections lead from these valves to the return risers and mains, the latter leading to the suction of the vacuum pump near which is placed a combined Webster Suction Strainer and Condenser Head (figure 4), containing a perforated screen for removing any chips or scale that would otherwise enter the pump.

The vacuum pump discharges to an air-separating tank from which the water passes through a sealed discharge-pipe to the feed-water heater (figure 5, page 30), or to a pump and receiver, the air escaping through a vent to the roof.

In the case of hotels, hospitals, or other buildings, where a temporary shut-down for overhauling or repairing the vacuum pump would be impracticable, pumps in duplicate are commonly installed, either of which is of sufficient capacity to handle the entire system.

In certain cases a steam-operated ejector is used in place of the duplicate pump.

The speed of the vacuum pump is automatically controlled by a Webster Vacuum Governor (figure 6), which may be set to maintain any desired degree of vacuum in the return lines. This, in combination with the Webster Water-Seal Motor at each radiator, makes the system automatic throughout, requiring little or no attention on the part of those in charge. The amount of vacuum expressed in inches of mercury

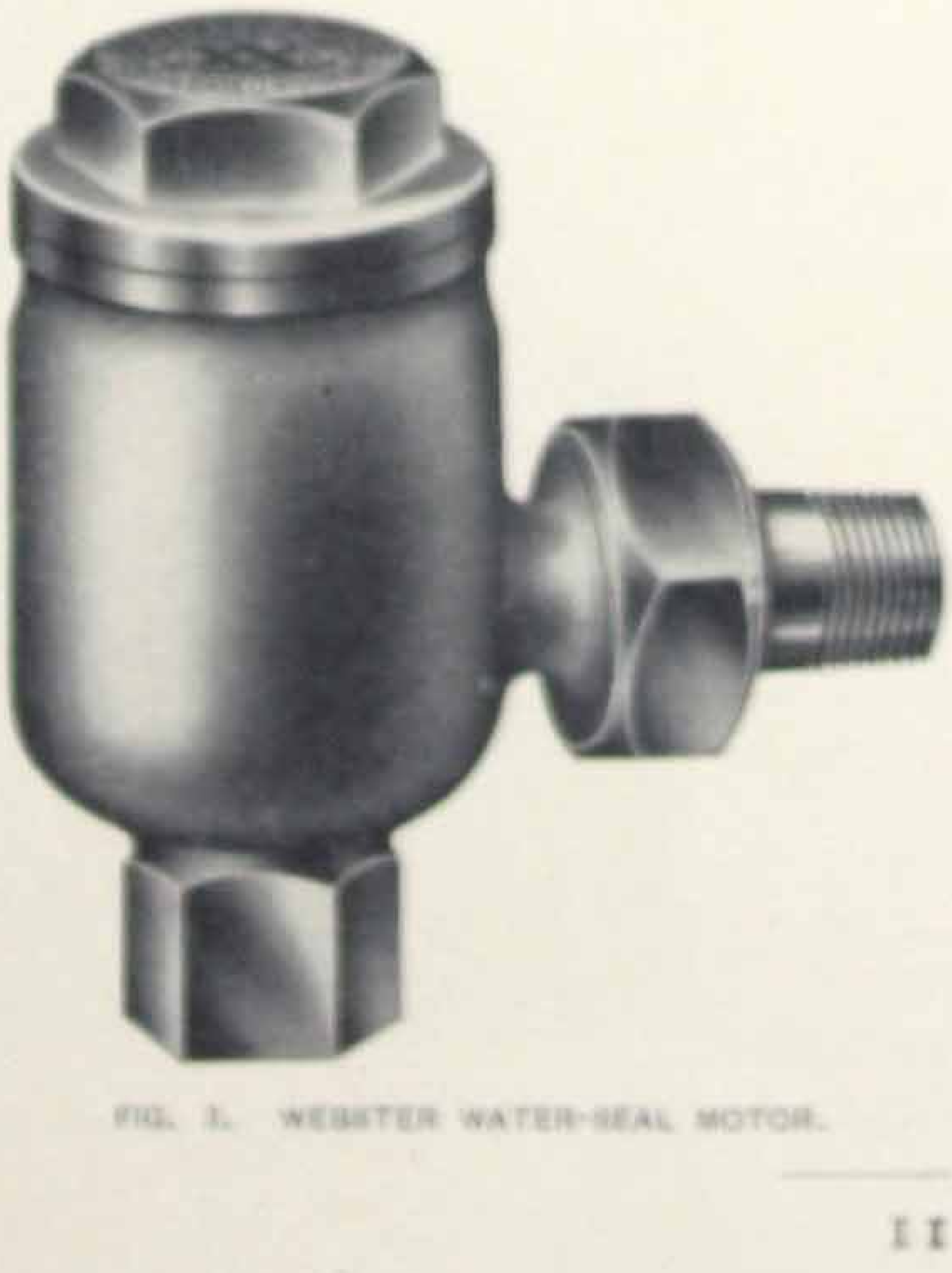

FIG. 3. WEBSTER WATER-SEAL MOTOR.

and the steam-pressure in pounds are indicated on gauges furnished with the system (figure 7).

When a Webster Feed-water Heater (figure 5), as described on pages 30 to 32, is used, it serves also as a receiver for the returns from the heating system, the boiler feed-pump drawing its supply directly from this heater. When a closed heater is used, a separate tank must be provided.

Drip points in the system of supply piping must be provided with Webster Water-Seal Motors, unless some special provision is made for removing the condensation at these drip points by other means.

The Webster System does away with all those little annoyances incident to ordinary systems of steam heating, and removes at the outset all uncertainty as to the successful operation of the plant.

Applied to manufacturing establishments it reduces the cost of production by utilizing in the most effective way possible, exhaust steam, the by-product of engines and pumps.

Discharge of Water and Air from Radiators and Mains

Our latest device for performing this duty, technically known as the Webster Water-Seal Motor, designed for use with the Webster System of Steam Circulation, is the result of years of experience in this line of work.

While extremely simple in its make-up and requiring no adjustment whatever, it responds to all demands made upon it, and automatically removes the water and air, insuring the radiators and mains being filled with steam.

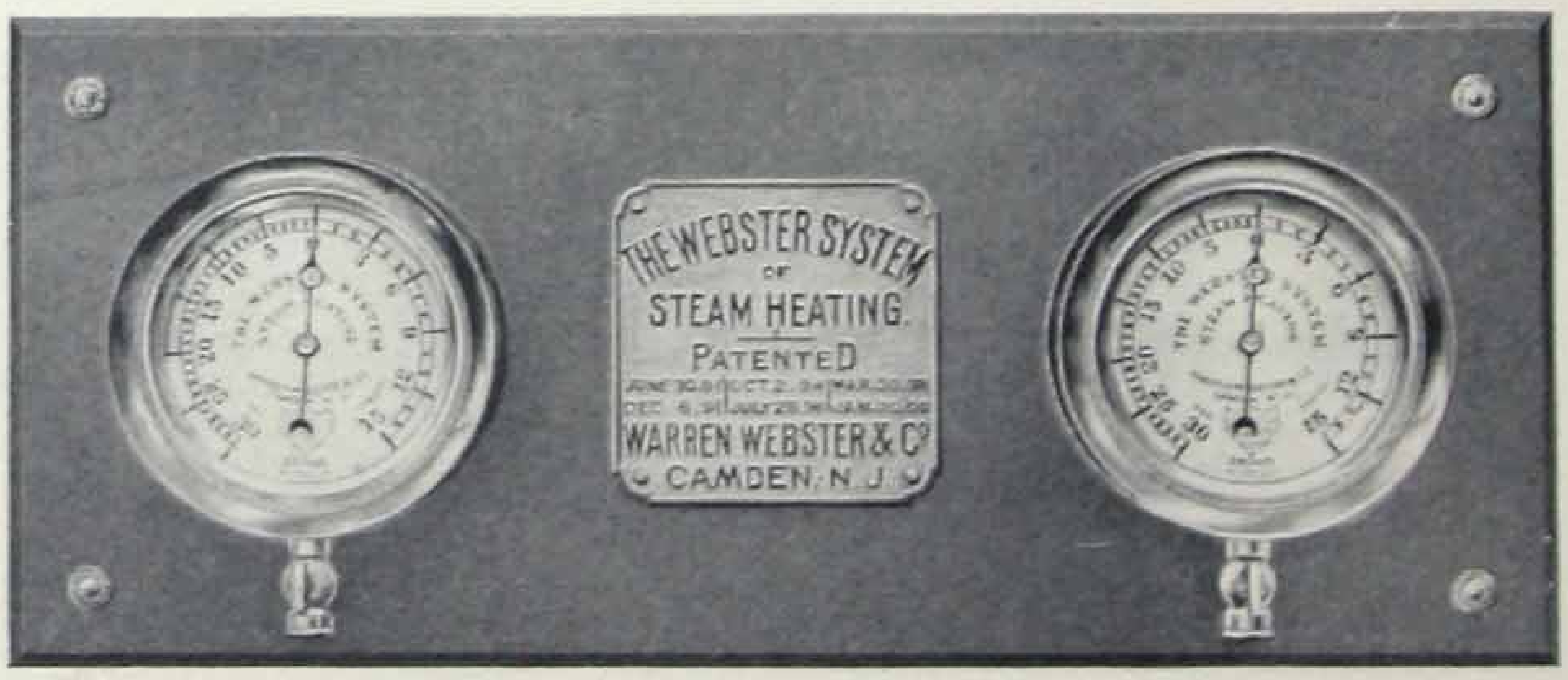

FIG. 7. WEBSTER COMBINATION GAUGES.

CIRCULATION FOR HEATING PURPOSES

This device, a view of which is shown in figure 3, is made in three capacities, and is fully described in a separate catalogue which we would be pleased to send upon request.

Back-pressure and Its Effects

Taking up in the order stated by Bolton the primary requirements of an effective exhaust steam heating system, we come first to the question of back-pressure.

Accumulations of air and water in pipes and radiators combine to interfere with the free passage of exhaust steam, necessitating the carrying of back-pressure unless these are removed by mechanical means. The vacuum pump of a Webster System, combined with the other special appliances, accomplishes this, and also facilitates the passage of steam.

Back-pressure systems always require a pressure in the radiators above that of the atmosphere to expel the air, regardless of the frictional resistance of the piping or the extent of the system.

A back-pressure valve, provided with removable or adjustable weights for the purpose of creating the required resistance to the flow of steam, is placed upon the outlet to the atmosphere, and is capable of being so loaded as to impose upon the engines or pumps, a back-pressure sufficient to impart the necessary velocity to the steam to cause it to flow through mains and branches, and into radiators and coils, at sufficient pressure to force out the air and gases.

Much has been written in regard to the uneconomical effect of back-pressure in engine and pump cylinders; the actual operation can be readily appreciated by any one familiar with the expansion of steam within these cylinders. At whatever points the initial pressure and back-pressure stand, the disadvantage of the latter is relative not to the former, but to the mean effective or average pressure above the atmosphere on the power side of the piston.

The necessary back-pressure must vary considerably with local conditions, increasing as the distance it is required to force the steam increases. It is due not only to the friction of the supply main, but also to the necessity for maintaining, in all the radiators, a pressure above that of the atmosphere, in order to expel the air. It results in loss of energy, or increase of fuel consumption, in the same proportion that such back-pressure bears to the total mean effective pressure above the atmosphere, and becomes a greater percentage of loss in the otherwise more economical types of engines in which steam is used expansively.

The loss due to back-pressure increases as the load, or total mean pressure decreases. This is shown in the following table. When the mean effective pressure is forty pounds per square inch, the loss of power (or fuel) is 2.4 per cent. for a back-pressure of as little as one pound; while for a back-pressure of five pounds the loss is 11 per cent., and for ten pounds it is 20 per cent.

Table showing approximately the loss in power developed, or increase in fuel required, due to back-pressure upon an engine.

M. E. P.	BACK-PRESSURE ON ENGINE IN POUNDS.									
	1	2	3	4	5	6	7	8	9	10
30	3.23	6.26	9.09	11.76	14.30	16.68	18.90	21.01	23.04	25.00
31	3.13	6.06	8.82	11.44	13.90	16.20	18.41	20.48	22.50	24.40
32	3.03	5.88	8.58	11.12	13.50	15.78	17.92	20.00	21.96	23.80
33	2.94	5.72	8.34	10.80	13.15	15.36	17.50	19.52	21.42	23.30
34	2.86	5.56	8.10	10.52	12.80	15.00	17.08	19.04	20.97	22.70
35	2.78	5.40	7.89	10.24	12.50	14.64	16.66	18.64	20.43	22.20
36	2.70	5.26	7.68	10.00	12.20	14.28	16.31	18.16	19.98	21.74
37	2.63	5.12	7.50	9.76	11.90	13.98	15.89	17.76	19.57	21.28
38	2.56	5.00	7.32	9.52	11.65	13.62	15.54	17.39	19.15	20.83
39	2.50	4.88	7.14	9.32	11.35	13.32	15.22	17.02	18.75	20.41
40	2.44	4.76	6.99	9.08	11.10	13.04	14.91	16.67	18.37	20.00
41	2.38	4.66	6.81	8.88	10.87	12.76	14.58	16.33	18.00	19.61
42	2.33	4.54	6.66	8.70	10.64	12.50	14.29	16.00	17.65	19.23
43	2.27	4.44	6.52	8.51	10.42	12.25	14.00	15.88	17.31	18.87
44	2.22	4.35	6.38	8.33	10.20	12.00	13.73	15.38	16.98	18.52
45	2.17	4.26	6.25	8.16	10.00	11.96	13.46	15.09	16.67	18.18

Under the old practice, the only means of reducing the back-pressure lay in increasing the size of the pipes throughout, greatly adding to the cost of the plant. The back-pressure necessary, even then, especially in the case of plants made up of widely-scattered buildings, was often so great as to seriously affect the economical operation of the engine.

CIRCULATION FOR HEATING PURPOSES

With ordinary systems the colder the weather the greater the back-pressure generally carried. In such systems the exhaust steam will often be seen emerging from the escape-pipes in increasing quantity as the severity of the weather increases. The effect is but natural: in the effort to produce a greater pressure, more steam is used in the engines than can be condensed in the heating system, and the surplus is discharged into the air through the back-pressure valve. Under these conditions the increased demand for steam often imposes so great a duty upon the engines that it is more economical to use live steam at the required pressure for heating, and to waste the exhaust to the atmosphere.

If it is attempted to make good a lack of heat by increasing the pressure at the entrance to the system, an increase from atmospheric pressure with steam at 212° Fahr. to five pounds pressure adds but 16° to the steam temperature, and an increase to ten pounds adds but 28°. On the assumption that the heat given off is approximately proportional to the difference in temperature between the steam and the surrounding air, the increased rates of condensation would be:

11.1 per cent. for five pounds pressure, and
19.5 per cent. for ten pounds pressure.

The loss of efficiency in the engine due to back-pressure offsets this seeming gain, even under the most favorable conditions, when the weather is most severe. During moderate weather there is a decided loss, owing to wasting the excess exhaust steam which the engine gives off, at the higher back-pressure.

Bolton points out, in his excellent paper previously referred to, that,

"It is doubtful if the above added speed of radiation can be attained with the ordinary radiator, which does not so effectively permit the circulation of the outer air over its surfaces as to enable such an advantage to be gained . . . .

"The addition of this 'back-pressure' is a direct expense either in the form of fuel for the increase of pressure if live steam be used, or by reason of the retarding effect upon the piston of the engine if exhaust steam be utilized.

"Therefore, unless the radiating surface provided be inadequate for its work, no advantage has resulted, inasmuch as the cost of the higher pressure steam has only increased the rate of diffusion of heat per square foot.

"It has been argued that the addition of initial pressure to a steam engine with a given point of cut-off offsets a 'back-pressure' of a similar extent, but the resistance of a given 'back-pressure' requires a full equivalent free of all losses, not to the initial pressure, but to the average or mean effective pressure on the pushing side. The average must be such that the terminal pressure shall be so raised as to afford the required 'back-pressure.' In an engine supplied with steam at eighty pounds pressure, where at one-quarter cut-off the mean effective pressure is, say 41.78 pounds, a back-pressure of ten pounds per square inch is equivalent to one-fourth of the total force of the engine, and the increase of boiler-pressure required to make up for it would amount, not to ten pounds, but more nearly to fifteen pounds, per square inch.

"With the direct-acting steam pump, a class of steam machine very commonly applied to this work, the addition of 'back-pressure' is still more deleterious, as it forms a direct resistance to the terminal pressure at the end of the stroke, and, as these pumps are proportioned so that their full stroke is just attainable with the normal terminal pressure, the addition of 'back-pressure' causes the pump to short-stroke, largely decreasing the work of the pump, and increasing the clearances or waste spaces in the steam cylinders. To overcome this difficulty when a 'back-pressure' is expected, it is customary to employ a pump with cylinders of a larger size than is normally necessary, resulting in a permanent loss of efficiency.

"Few firemen can be depended upon to increase pressure as the 'back-pressure' creeps up in a heating system, and not all boilers are designed to stand such increased pressure. Therefore, a common result of 'back-pressure' in engines automatically controlled is a decrease in the range of expansion, with resultant loss of economy."

Minimum Back-pressure

The ability to distribute a volume of exhaust steam, not of itself sufficient to exert a serviceable pressure in the mains, and to force an effective circulation, is abundantly worthy of the consideration of all heating engineers. Under the usual methods of steam heating it is necessary to carry a back-pressure, even during mild weather, when the full efficiency of the radiating surface is not demanded, and when there may be but few of the radiators of an extensive system in actual operation. In many instances there is not sufficient exhaust steam to fill the mains and force a circulation in a gravity system, in which case the shortage must be supplemented by live steam, the evaporation of which necessitates additional expense for fuel.

With the Webster System, under similar conditions, the limited volume of exhaust steam may be distributed and utilized in the radiating surface at a pressure less than that of the atmosphere without calling to its aid any supplemental live steam supply. The engines under these conditions will be operated with the highest attainable economy when used in connection with heating.

With the Webster System, the steam supply to the heating mains may be either at, or slightly above or below, the pressure of the atmosphere, as required for the best operating conditions in each plant.

Upon opening the supply-valves, the steam immediately flows into the lower pressure within the radiators, expanding and filling the entire space, driving the air before it. As the steam reaches the Webster Water-Seal Motor placed at the lowest and farthest point of each radiator, its progress is effectively checked, and as the air and water of condensation accumulate, the Water-Seal Motor ejects them into the return system.

The steam is thus confined within the radiators until it has condensed, the condensation creating a partial vacuum which induces a flow of steam from the supply-pipes into the radiators.

Equable Steam Distribution

By the Webster System it is possible to distribute a minimum volume of steam to all points requiring but a moderate heat during mild weather; it is also possible to automatically reduce the amount of steam required to maintain heat at night, since a volume, less than that sufficient to completely fill the radiator at atmospheric pressure, may be distributed wherever needed, with a pressure in the mains below that of the atmosphere, thus reducing the general temperature of the radiators, the rate of condensation during the hours when the building is not occupied, and the cost of fuel during that time.

With this system, it is no longer necessary to "roast" in some portions of a building, in order to secure the proper circulation in the radiation in the more remote parts where a comfortable temperature is desired.

Removal of Condensation

Unless provision is made for the proper removal of condensation from the supply-mains, this water will interfere with the passage of steam, and a higher initial pressure will be required than would otherwise be necessary, in order to overcome this resistance.

Furthermore, dry steam, not wet, is what is wanted in the radiators, and unless this water be removed, a certain portion of it will be swept along and picked up by the rapidly moving current of steam.

With the Webster System the removal of condensation is effectively accomplished by either Webster Water-Seal Motors or traps, or by special arrangement of the piping, best suited to the conditions as based upon wide experience in similar installations.

Lifting the Condensation

It is frequently desirable to locate some radiating surface at a point lower than the one practicable for the main return. With the Webster System it is possible to lift the condensation by means of the difference in pressure between the supply and return lines. It has been discovered that it is possible (by reason of the mixture of water and air in the returns) to lift this condensation even higher than the difference in pressure would raise a solid column of water. For similar reasons it is possible to successfully drain the supply pipes into returns elevated above them, or to run returns overhead as a substitute for the costly trenching that might otherwise be imperative in order to avoid doorways and obstructions.

Water-Hammer

In buildings equipped with an ordinary steam heating system, water-hammer in the pipes or radiators is one of the unpleasant and not uncommon accompaniments of this method of heating.

CIRCULATION FOR HEATING PURPOSES

In piping, this is generally due to the tendency of the steam under certain conditions to force two separate volumes of water together from opposite directions, which action is accompanied by the shock called "water-hammer."

With the Webster System, the flow of steam through the pipes is always in the direction intended and the water is constantly removed, which condition is mechanically maintained by the action of the vacuum pump.

To prevent water-hammer in the best possible designs of both the one-pipe and two-pipe gravity heating systems, it is necessary that the radiating surface either be operated to its utmost capacity, or be entirely shut off, since, under certain improper adjustments of the valves, the condensation will back up in the radiators, accompanied by annoying gurgling or hammering.

With the Webster System the condensation is removed from the radiators as it accumulates.

Air-binding and the Removal of Air

At first thought one might suppose that with a heating system in which the water is returned to the boilers, little trouble would be experienced from air in the pipes after the water had once been boiled.

As Bolton puts it, however, "The inherent affinity of water for the absorption of air and gases is by far the most troublesome characteristic of water under evaporation and condensation.

"The exchange is mutual, although in an unequal and inverse ratio, inasmuch as air at increasing temperatures is capable of an increasing absorption of moisture, while water absorbs more air and gases at decreasing temperatures.

"Water at the freezing point, 32°, which has been exposed to the atmosphere, contains as much air as 2½ per cent. of its volume, but at 68° its capacity is reduced to 1.7 per cent., and at 212° is approximately 0.6 per cent.

"Since air is a poor conductor of heat, it follows that that portion of a radiator or coil from which the air has not been expelled is practically worthless as a heating surface. The air that tends to lodge in the pipes at ends, turns, bends and offsets, forms air-pockets and interferes with or prevents the passage of steam.

"In practice it is found that air that enters on the suction side of drips, in the make-up water (that is the fresh water that must be supplied to make up for the slight leakages that always occur), and the air absorbed by the water while held in the receiving tanks, is sufficient to require that very efficient means be provided for its removal, and its removal must be practically continuous."

The removal of this gas or air is thus of the utmost necessity, hence with ordinary gravity systems "air-valves," designed for this purpose, are commonly used. They afford a minute opening for the exit of the air, which opening closes upon the approach of steam. The air, however, must be forced out by steam of a higher pressure than the atmosphere into which the air escapes, in order to find an exit by this means.

Thus the direct effect of the pressure of air-gases is to demand a pressure of steam for heating work which would otherwise be unnecessary.

These air-valves in practical operation are unable to pass more than a portion of the air with which the system is charged at starting, and their performance is sometimes erratic. At times, also, instead of the air being ejected, it will be drawn in through the air-valves. This takes place whenever steam is shut off, since a partial vacuum will naturally result, and the outside air will be drawn into the radiator to take the place of the steam condensed.

The air-gases emitted into rooms not only have an unpleasant odor, but their emission is often accompanied by an annoying whistling. In certain classes of buildings, therefore, special lines of pipes for conducting this air to some vent or sewer are thus rendered necessary, which, obviously, adds to the expense of the installation.

Bolton states in practically these words that:

"Air is heavier than saturated steam. . . . . . . One pound of each at atmospheric pressure bear the relation of 13.14 cubic feet of air at 62° Fahr. to 26.36 cubic feet of steam at 212° Fahr. The air, however, when in contact or association with the steam and subjected to its temperature of 212°, becomes expanded (by 1/400th part of its volume for each degree) to 17.5 cubic feet, so that the relation in weight then stands as 1 to 0.66.

CIRCULATION FOR HEATING PURPOSES

''In this heated condition the air has a strong affinity for water, and will absorb and hold as much as 265 grains per cubic foot. Thus the pound of air-gases holds in suspension 0.69 of a pound of water, and becomes a still heavier body to that extent.

''As the steam-vapor condenses, it leaves its now dissociated air in this saturated and heavy condition, and it may be seen to be a mechanical operation which drives the excluded air into the upper portions or extreme ends of radiators and coils. It therefore follows that steam, being once fully admitted into the contents of an enlargement, the air-gases, afterwards liberated by condensation, are best accumulated and removed off at the point of drainage,''—that is, at the low point at the return end of a radiator or coil.

With the Webster System no air-valves are required, since the Webster Water-Seal Motor placed at the return end of each radiator serves to remove from the system both air and water.

Modulation of Temperature

In steam heating systems as commonly installed, if it is desired that any radiator shall be shut off, it is necessary to close not only the inlet valve, but the outlet valve as well. Otherwise, the steam already within the radiator will condense, and a partial vacuum result. The drip-valve being open, steam will be drawn from the common return-line to take the place of the steam condensed, and thus fill the radiator which it is desired should become cool.

The most effective treatment of the condensation in such systems would be the continuous disposal by a gravity flow, through independent drips from each unit of radiation to a sealed return-main, but this is hardly practicable.

The steam inlet to a radiator, when partially closed, limits the quantity of steam admitted, and consequently regulates the amount of heat emitted from such radiators, with the result that, when the steam supply is so restricted, such a modulation may be secured as is necessary during mild weather.

This advantage secured by means of the Webster System, may be had without the accompaniment of air-binding, water-logging or water-hammer common in other systems where it is attempted to throttle the steam supply.

The reason for this is that a lower pressure is automatically maintained in the returns than that in the radiators or coils.

The ability to modulate the temperature of the radiation makes it possible to use fewer radiators or coils than in ordinary steam heating systems which are sometimes arranged with several radiators or coils in a room, one or more of these being used at a time to suit the weather conditions.

With the Webster System the general control is placed in the hands of the operating engineer, and the control of the room temperature in the hands of the occupant.

Application to the Blower System

The Webster System is frequently applied to buildings heated by the Blower System.

With some types of heater sections, special tappings are required to make this system most efficient.

It is best to connect the sections of the heater independently, treating each as a separate unit as in the case of direct radiators or coils.

The application of the Webster System to blower coils overcomes the necessity of carrying a pressure of two or three pounds in them to expel the air. Some of our largest installations are in connection with fan systems.

Efficiency with Compound Engines

The perfect disposal of exhaust steam under the Webster System, at a pressure as low, or lower, than that required to exhaust freely to the atmosphere, permits of the use of the more economical compound engines and pumps, and consequently enables the designing engineer to employ such engines without the necessity of giving a thought to the evils of "back-pressure" on his large low-pressure cylinders during the steam heating season.

Condensing Plants

We desire to invite special attention to the benefits obtainable by the Webster System in the utilization of a part of the receiver steam of plants equipped with compound condensing engines. While this field is a comparatively new one, the measure of our success in a number of important installations has assured us that its general adoption by such condensing plants as are now heated by live steam, would be a thoroughly sound investment from a purely economic standpoint.

Changing Live to Exhaust Steam Heating Systems

One field in which we have had unqualified success is that of changing live steam heating plants so that exhaust steam, otherwise wasted, is utilized for heating.

Many manufacturing plants are to-day using live steam for heating where with proper changes the exhaust from the main engine would not only be capable of heating the buildings, but could also heat an abundance of water for manufacturing purposes, as in bleacheries, dye-houses, laundries, and the like.

Owners are often deterred from changing an existing live steam plant believing it will be necessary to discard all the supply and return mains and substitute larger ones.

With the Webster System this is generally unnecessary, often the only changes required being the addition of Webster Water-Seal Motors at the return end of the coils, the installation of a vacuum pump with its automatic appliances, and the changes in power-house piping necessary to supply exhaust instead of live steam to the mains.

The surprising thing is that in many cases no additional radiating surface is necessary, the increased efficiency due to the thorough removal of air and condensation more than off-setting the loss of heat given off by the coils due to the lower temperature of the steam used.

Live Steam Installations

While engineers are aware of the increasing use of the Webster System for utilizing exhaust steam, they are perhaps not as familiar with our arguments in favor of the adoption of this system for circulating live steam at low pressure.

We therefore submit the following:

1.—A large saving can be made in the cost of pipe, valves, fittings and covering, since mains and connections are much smaller in a Webster System than in the case of an ordinary gravity or trapped layout.

2.—Less piping and fewer valves are necessary with the Webster System than with ordinary two-pipe systems with air-valves connected with air-lines.

3.—In the case of widely-scattered buildings, it is necessary in many plants to carry a pressure on buildings near the power-house considerably higher than is necessary to heat them, in order that buildings farther away shall be supplied with steam at the proper pressure. The Webster System overcomes this difficulty.

4.—With the Webster System deep trenching is avoided, which is necessary with gravity or trapped returns from scattered buildings to secure the proper pitch for draining the pipes. The vacuum pump permits the running of the returns practically level.

5.—In certain plants it is necessary to lift the condensation in the returns. The Webster System will accomplish this, whereas the gravity system will not.

6.—A saving in steam consumption can be effected, (1) since in mild weather the mains and radiators may be filled with steam at a pressure below that of the atmosphere; (2) because the supply of steam to the radiators can be throttled so that only a portion of the radiator is kept steam-hot; (3) on account of the smaller loss by radiation from mains and returns, these being smaller and at a lower temperature than with gravity systems; and (4) because steam may be shut off entirely from the buildings for hours at a time and turned on again without the accompaniment of water-hammer and air-binding, which are all too common with ordinary systems. The exhaust from the vacuum pump is utilized in heating.

7.—In case an electric vacuum pump is used in place of a low-pressure steam pump, other features may be advanced in favor of the Webster System, such as the elimination of the pressure-reducing valve; the operation of the system when a vacuum is carried directly on the boiler; the maintenance of a circulation of steam all night, regardless of the pressure on the boiler, the fire merely being banked and vapors only allowed to generate, the vacuum being maintained and the condensation being delivered back into the boiler by means of the electric pump.

Pipe-sizes, etc.

With the Webster System a great saving is made in the size and cost of pipes, valves, fittings and covering, since the difference in pressure between the supply and return-lines maintained by the vacuum pump is much greater than in the case of a gravity system, hence the velocity is much greater and pipes much smaller than are commonly used for a given service are found to be ample for the work.

There are but two lines of pipes in the Webster System, whereas in many gravity lay-outs an air-line is necessary in addition to the supply and return lines.

With the Webster System the vacuum in the return-line is carried as far as the Webster Water-Seal Motor placed on each radiator or coil. This motor permits any air or water present in the radiator to freely escape, at the same time preventing the escape of steam.

The size of the returns is only a fractional part of that required for a gravity system, since the return circulation is mechanically maintained by means of the vacuum pump.

No return-valve nor air-valve is necessary. The Webster Water-Seal Motor takes the place of both, in addition to performing the functions above named. No check-valves are necessary in the returns.

The supply-valves are smaller than are used with gravity systems.

Central Heating Plants

Perhaps in no class of heating does the Webster System show so great a superiority over other methods as in circulating exhaust steam from a central plant through widely scattered buildings, returning the condensation to a point near the source of supply where the vacuum pump is located.

This system places the control of the distribution, both as to supply and return, in the hands of the engineer, everything necessary in this connection being located at hand in the power-house, whereas with steam heating systems as commonly arranged, pumps and receiving tanks have to be placed in the several buildings to provide for returning the condensation to the boiler-house.

Special appliances are provided when necessary in connection with the Webster System, to secure a uniform distribution of steam in each building regardless of its distance from the power-house.

We have many central heating plants which have been in successful operation for years, where exhaust steam is circulated through the radiators or coils in buildings from 1000 to 2000 feet from the source of steam supply, and in some cases at even greater distances ; all without excessive back-pressure upon the engines.

Other Applications

In addition to the foregoing, we wish to state that Dry-Kilns, Paper-Machines, Slashers, Drying-Cylinders, and other special machines with large "appetites" for steam, can be and in many instances are successfully operated with notable economy by the Webster System.

Advantages

Summarizing the main advantages of the Webster System, these are—

Little or No Back-pressure. A perfect and continuous circulation of exhaust or live steam, or a combination of both, throughout single buildings or those scattered over a wide area, with little or no back-pressure.

Live Steam Heating. Decided economy and perfect control when applied to live steam systems.

Saving of Condensation. A thoroughly efficient provision for the removal and disposal of all the products of condensation, which, after being relieved of air and gases, become available feed-water.

Noiseless Operation. Impossibility of producing "water-hammer" by improper manipulation of valves.

Control. Perfect control of the circulation at will.

Modulation of Temperature. The ability to maintain a modulation of heat in any of the radiators of a heating plant, without impairment of the highest efficiency of the remaining ones, thus rendering it possible to obtain at will the mild heat of a hot-water system, or the more intense heat of steam.

Lifting Condensation. Return of the condensation from a moderate distance below the line of drainage, thereby permitting radiators to be placed below the level of the return-mains, if necessary.

Economy of Operation. A perfect distribution of even a small volume of steam to any desired part of an extended system of radiation, for use during mild weather, thus securing the greatest economy.

CIRCULATION FOR HEATING PURPOSES

Simplicity. Absolute simplicity in the control of each radiator in the building by tenants or others inexpert in such manipulation, there being but a single valve to operate on each radiator. Aside from this valve the system is entirely automatic with its vacuum pump governor and its Water-Seal Motors.

Cost. Low cost of installation, due to small sizes of pipes and connections. No air-valves nor return-valves.

EVIDENCE

THE brief summary following is intended merely to illustrate the wide-spread adoption and broad scope of application of the Webster System, as shown by the diversified character of the buildings in which it is installed. The list is not complete, as the number of Webster System installations is now nearly thirty-five hundred.

We are prepared to furnish upon inquiry, the name and locations of the installations in any desired classification, or a general list of the installations in any specific locality, to which we will have pleasure in referring prospective purchasers.

Agricultural Implement Manufacturers	15
Automobile and Carriage Manufacturers	26
Asylums, Homes, Hospitals and Sanitariums	181
Bakers and Confectioners	40
Brick and Pottery Manufacturers	21
Builders' Supplies Manufacturers	24
Cash Register Manufacturers	2
Catholic Institutions	70
Central Heating Plants (three or more buildings heated from a central source)	235
City, County and State Buildings and Institutions	241
Clothing and Wearing Apparel Manufacturers	20
Churches	12
Colleges, Schools and Universities	209
Department Stores and other Large Retail Stores	61
Drugs and Chemical Manufacturers	18
Electric Railway Buildings	16
Electrical Supplies Manufacturers	22
Foodstuffs and Grocers' Supplies Manufacturers	31
Foundries, Brass, Iron and Steel Works	135
Furniture and Wood-working Plants	93
Greenhouses and Nurseries	9
Hardware and Housefurnishings Manufacturers	52
Hotels and Apartment Houses	239
Jewelry, Watch and Clock Manufacturers	12

CIRCULATION FOR HEATING PURPOSES

Libraries, Clubs and Secret Society Buildings	28
Machinery Manufacturers	143
Metal Goods Manufacturers	22
Mining Companies' Buildings	75
Office and Business Buildings	344
Optical Goods and Camera Manufacturers	3
Paint and Varnish Manufacturers	30
Paper and Pulp Mills	54
Penitentiaries and Prisons	25
Piano and Musical Instrument Manufacturers	19
Printers and Publishers	43
Railroad Supplies Manufacturers	10
Railroad Shops and Freight Stations	61
Railroad Terminals and Office Buildings	51
Rubber Goods Manufacturers	14
Shoe Manufacturers	42
Sewing Machine Manufacturers	8
Slasher Equipments for Cotton and Textile Mills	64
Soap Manufacturers	8
Stationery Manufacturers	12
Tanneries and Leather Goods Manufacturers	36
Telephone Companies' Buildings	13
Textile Mills and Manufacturers	243
Theatres and Amusement Buildings	18
Tobacco Manufacturers	10
United States Government Buildings and Institutions (including two Mints)	28
Y. M. C. A. Buildings	14

List to July 31, 1907.

THE WEBSTER FEED-WATER HEATER

THE Webster Feed-water Heater, while not an essential part of the Webster System, is so commonly used in connection with it that a few words in regard to this apparatus may be of interest.

The heater consists of a cast-iron receptacle in which cold water and exhaust steam are brought into direct contact.

It is provided with a Webster Oil Separator which is made a part of the heater construction, which effectually and completely removes the oil present in the exhaust steam before it enters the heater; also with automatically-regulated water supply and overflow; quick-opening drain-valve or blow-off; sealed outlet for the heated and purified water fed to the boiler feed-pumps; charging and cleaning doors for the filter; removable tray-doors; combination vent and inlet air-valve; gauge-glass, and other fixtures.

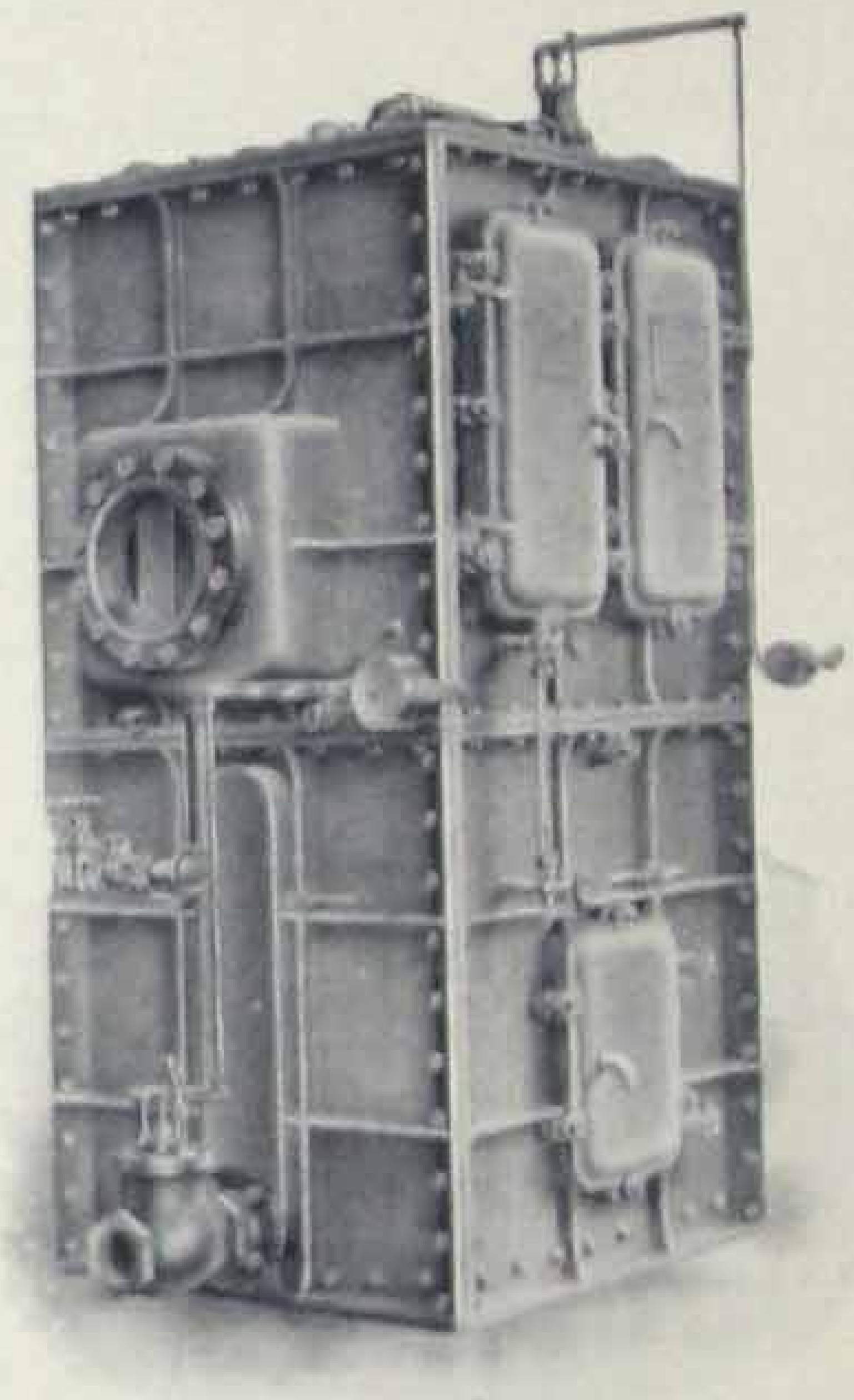
FIG. 5. WEBSTER FEED-WATER HEATER.

Water-supply

The water-supply to the heater is controlled automatically, as shown in figure 8, the valve for this purpose being operated by a series of levers connected to an open copper sink-pan (performing the functions of a float), placed within the heater shell.

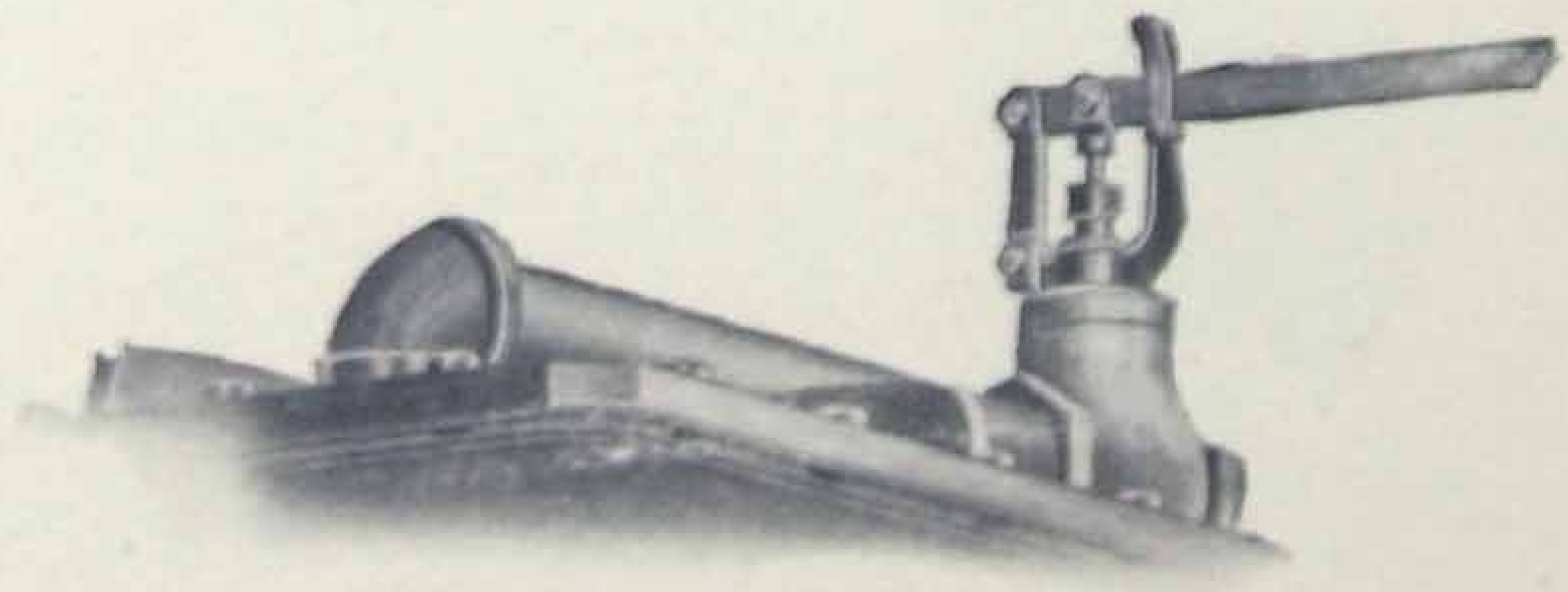
FIG. 8. AUTOMATIC WATER SUPPLY.

By this arrangement a constant water level is automatically maintained within the heater—the amount of water to the heater being

CIRCULATION FOR HEATING PURPOSES

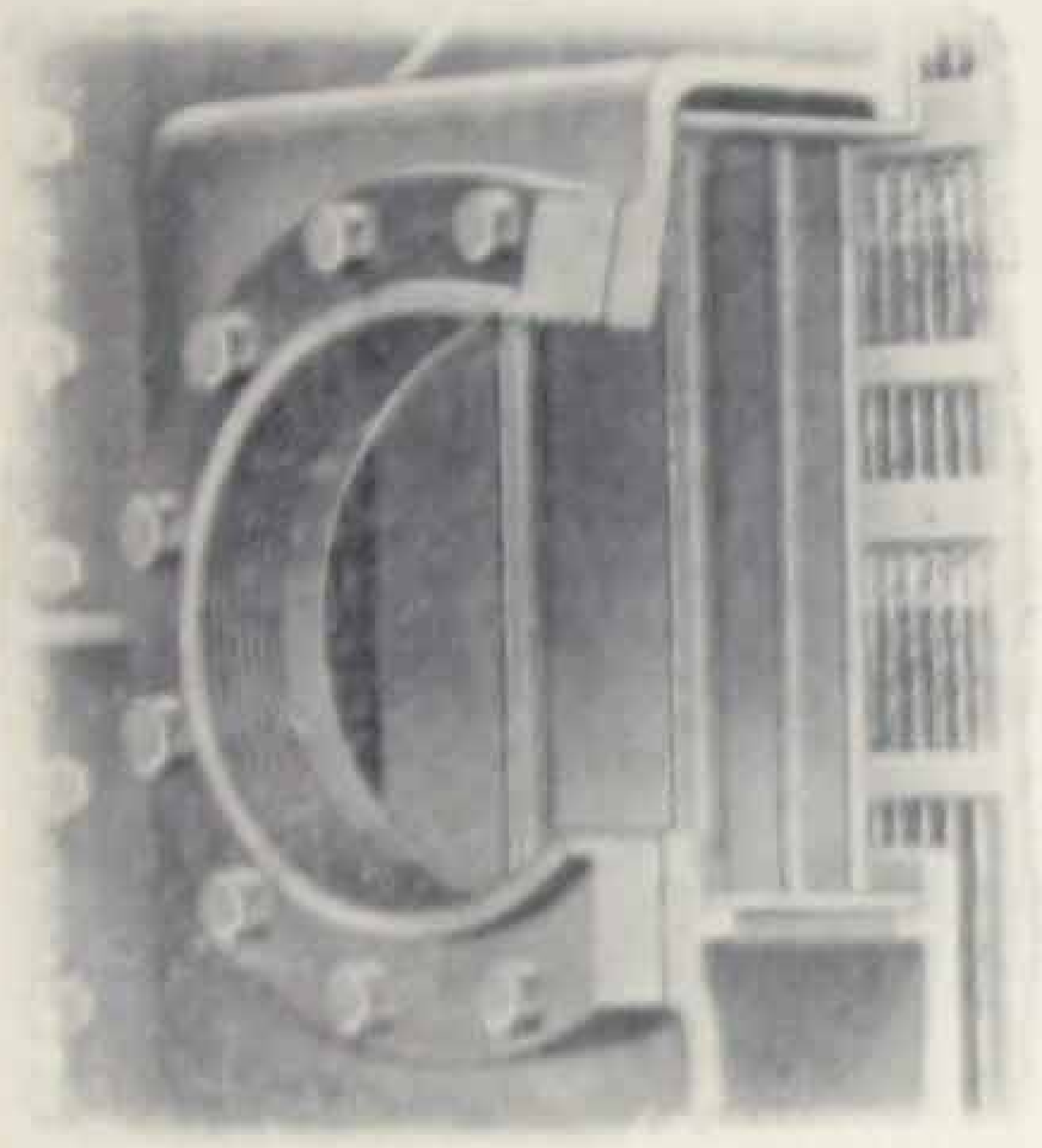

FIG. 9. EXHAUST STEAM INLET, SHOWING OIL SEPARATOR BAFFLES.

increased or diminished, as may be necessary to furnish the required amount of feed-water for the boilers. When the water of condensation, returning from the heating system or other sources of drips, is more than sufficient for the immediate requirements, it is held in the storage space provided for this purpose. An automatic overflow is provided to prevent the heater from filling to a dangerous level.

Any floating scum or impurities may be drawn off at the overflow point.

(When desirable, under certain conditions of operation, a special boiler feed-pump governing-valve may be furnished instead of the water-regulating valve referred to above. This valve is placed in the steam supply pipe to the pump, and is operated by the same system of levers, rods, and pan, automatically feeding the boilers with hot water, while the cold water is introduced into the heater through a hand-controlled valve.)

Owing to the saving of water by condensing the exhaust steam used for heating, there is effected an economy in the amount of supplemental water required for the boilers of about 14 per cent., depending upon the initial temperature of the water supplied. Aside from its commercial value, this is an important factor in the purifying efficiency of the heater —it means so much less cold impure water with which to deal.

Steam-supply

The steam supply enters the heater through a valved branch from the main exhaust pipe. This obviates the necessity of expensive piping, such as is necessary in other

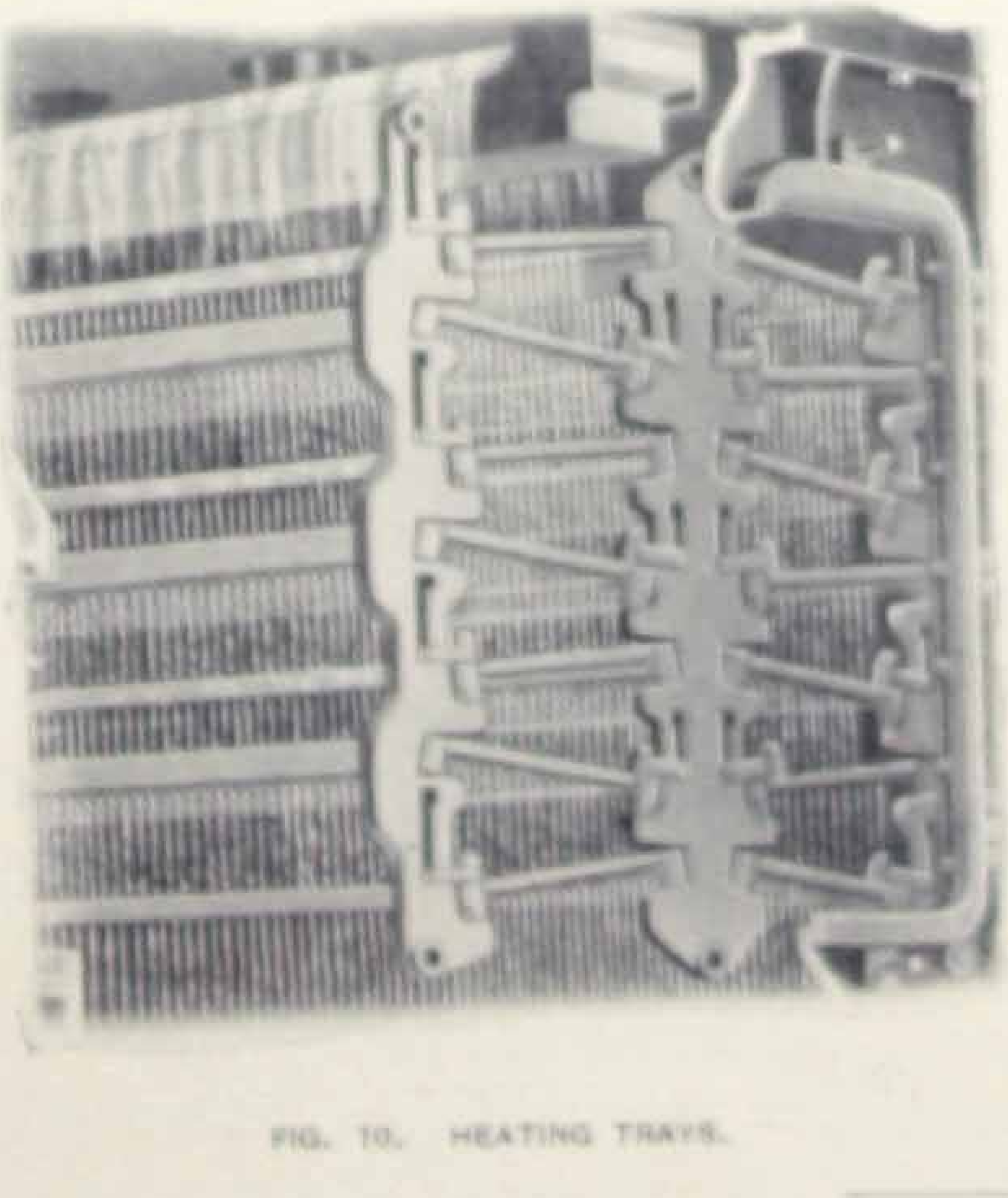

FIG. 10. HEATING TRAYS.

makes of heaters, and further obviates the difficulty attendant upon taking all of the exhaust steam with its entrained oil through the heater. It also prevents the waste of water absorbed by the steam not condensed.

Oil Separation

In the rectangular casting, shown in figure 9, forming the steam connection to the heater, there is placed an efficient Webster Oil Separator of large surface, constructed with steel baffles.

Heating Chamber

The feed-water entering the heater through the automatically-controlled valved inlet, passes into the water-seal distributing-trough, which has a wide extended lip. The water, overflowing from this trough in an even sheet, is distributed over a series of oppositely-inclined finely-perforated copper trays, arranged one above the other, as shown in figure 10, so that the water in its downward course falls from one tray to the other, and any water which does not pass through the perforations will fall upon the protruding upper edge of the next tray.

This arrangement retains the water in the heating chamber in a finely-divided state, until it has mingled with and been heated by the surrounding steam to the highest possible temperature, causing a liberation of gases and precipitation of solids. Ample space is provided to insure uniform distribution of the steam around the trays.

Filter

The filter is located in the lower compartment of the heater, and the filter-bed, commonly composed of coke or other suitable material, can be renewed whenever necessary.

The large doors at the front and back allow ready access to all parts of the interior of the filter compartment for charging and cleaning.

In General

These heaters combine the functions of a feed-water heater and a storage tank or receiver for returns from the heating system. They require less space and fewer pipe connections than a closed heater and separate tank and present a neater appearance.

The fact that over 2,250,000 horse-power of Webster Heaters have been sold is evidence of the good opinion in which they are held.

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